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(54) MOTOR CONTROL DEVICE AND METHOD THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a motor control device and a method for switching rectangular wave voltage drive and PWM wave voltage drive for improving the operating efficiency of a motor.

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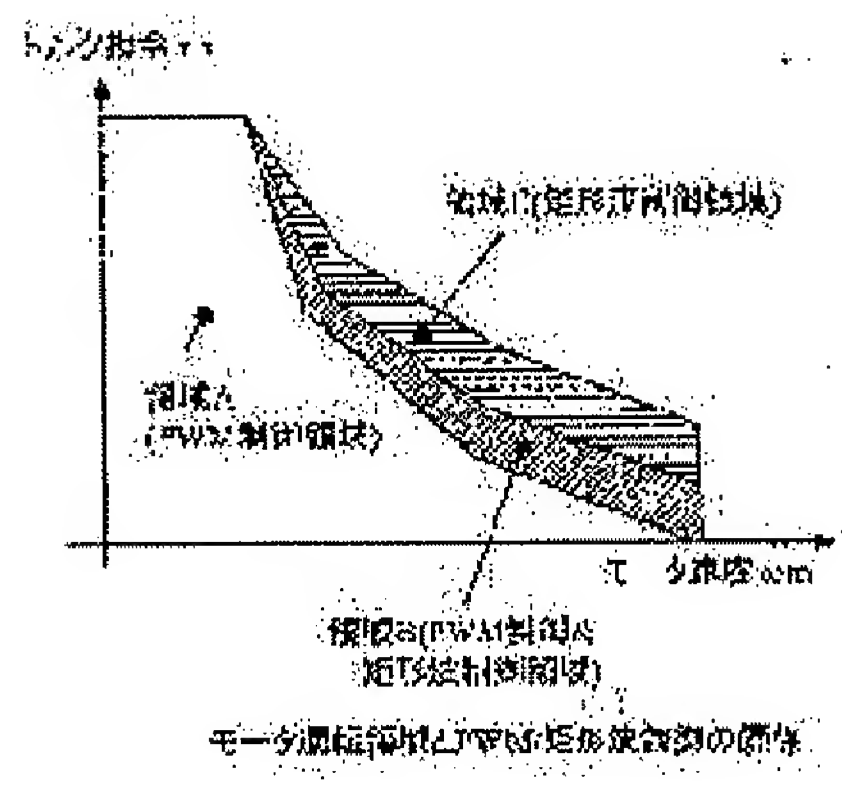

SOLUTION: The rectangular wave voltage drive driven by applying a rectangular wave voltage to an AC motor and the PWM wave voltage drive driven by applying a PWM (pulse width modulation) wave voltage to the AC motor are made possible. By using torque and a speed, the operation region of the AC motor is divided into a region A wherein the PWM wave voltage drive is conducted for obtaining high-speed responsiveness, a region C wherein the rectangular wave voltage drive is conducted for obtaining a high output, and an intermediate region B wherein either of the PWM wave voltage drive or the rectangular wave voltage drive can be conducted. When switching the rectangular wave voltage drive and the PWM wave voltage drive corresponding to a torque command τr and a motor speed ωm, loss maps of motor control systems in the rectangular wave voltage drive and the PWM wave voltage drive are possessed, and, in driving the AC motor in the intermediate region B, either of the rectangular wave voltage drive and the PWM wave voltage

drive whichever small in loss is selected.

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CLAIMS

[Claim(s)]
[Claim 1]
The square wave electrical-potential-difference drive circuit which impresses and drives a square wave electrical potential difference to an AC motor,
The PWM wave electrical-potential-difference drive circuit which impresses and drives an PWM (Pulse Density Modulation) wave electrical potential difference to said AC motor,
The rate detector which detects the rate of said AC motor,
The field A which performs said PWM wave electrical-potential-difference drive in order to obtain a high-speed response for the operating range of said AC motor with torque and a rate It classifies into the staging area B which can drive said square wave electrical-potential-difference field C which performs said square wave electrical-potential-difference drive in order to obtain high power, said PWM wave electrical-potential-difference drive, or drive. It is motor control equipment equipped with the change-over circuit which switches said square wave electrical-potential-difference drive circuit and said PWM wave electrical-potential-difference drive circuit according to a torque command value and said motor speed detection value,

Said change-over circuit is motor control equipment characterized by loss of said square wave electrical-potential-difference drive and said PWM wave electrical-potential-difference drives choosing little direction in having the loss map of the motor control system the case of said square wave electrical-potential-difference drive, and in said PWM wave electrical-potential-difference drive and operating said AC motor in said staging area B.
[Claim 2]
The square wave electrical-potential-difference command generation circuit which generates the square wave electrical-potential-difference command for impressing and driving a square wave electrical potential difference to an AC motor,
The PWM wave electrical-potential-difference command generation circuit which generates the PWM wave electrical-potential-difference command for impressing and driving an PWM (Pulse Density Modulation) wave electrical potential difference to said AC motor,
The power inverter circuit which changes direct current power into alternating current power according to said square wave electrical-potential-difference command or said PWM wave electrical-potential-difference command, and impresses driver voltage to said AC motor,
The rate detector which detects the rate of said AC motor,
The field A which performs said PWM wave electrical-potential-difference drive in order to obtain a high-speed response for the operating range of said AC motor with torque and a rate It classifies into the staging area B which can drive said square wave electrical-potential-difference field C which performs said square wave electrical-potential-difference drive in order to obtain high power, said PWM wave electrical-potential-difference drive, or drive. It is motor control equipment equipped with the change-over circuit which switches said square wave electrical-potential-difference command and said PWM electrical-potential-difference command according to a torque command value and said motor speed detection value,
Said change-over circuit is motor control equipment characterized by loss of said square wave electrical-potential-difference drive and said PWM wave electrical-potential-difference drives choosing the electrical-potential-difference command of little direction in having the loss map of a motor control system including said AC motor and said power inverter circuit the case of said square wave electrical-potential-difference drive, and in said PWM wave electrical-potential-difference drive and operating said AC motor in said

staging area B.

[Claim 3]

In motor control equipment according to claim 1 or 2,

Said change-over circuit is motor control equipment characterized by choosing said PWM wave electrical-potential-difference drive when a torque command value change exceeds the specified quantity in said staging area B.

[Claim 4]

In motor control equipment according to claim 1 or 2,

It has the disturbance judging circuit which judges the existence of the disturbance invasion to said motor control system,

Said change-over circuit is motor control equipment characterized by choosing said PWM wave electrical-potential-difference drive when judged with those with disturbance invasion to a motor control system in said staging area B and said field C.

[Claim 5]

In motor control equipment according to claim 4,

It has the current detector which detects the current of said AC motor,

Said disturbance judging circuit is motor control equipment characterized by judging with those with disturbance invasion when said motor current detection value change exceeds the specified quantity.

[Claim 6]

In motor control equipment according to claim 4,

Said disturbance judging circuit is motor control equipment characterized by judging with those with disturbance invasion when the variation of a motor rate is predicted based on a torque command value and the difference of this motor rate variation forecast and said actual amount of motor speed detection value changes exceeds a predetermined value.

[Claim 7]

In motor control equipment given in one term of claims 4-6,

Said change-over circuit is motor control equipment characterized by restricting a torque command value to the value according to a motor rate when judged with those with disturbance invasion in said field C.

[Claim 8]

In motor control equipment given in one term of claims 1-7,

Said change-over circuit is motor control equipment characterized by switching to said square wave electrical-potential-difference drive after said PWM wave electrical-potential-difference drive is performed beyond predetermined time in switching to said square wave electrical-potential-difference drive from said PWM wave electrical-potential-difference drive.

[Claim 9]

The square wave electrical-potential-difference drive which impresses and drives a square wave electrical potential difference to an AC motor, and the PWM wave electrical-potential-difference drive which impresses and drives an PWM (Pulse Density Modulation) wave electrical potential difference to said AC motor are enabled,

It is the motor-control approach which classifies into the staging area B which can drive said square wave electrical-potential-difference field C which performs said square wave electrical-potential-difference drive, said PWM wave electrical-potential-difference drive, or drive in order to obtain Field A and the high power which perform said PWM wave electrical-potential-difference drive in order to obtain a high-speed response for the operating range of said AC motor with torque and a rate, and switches said square wave electrical-potential-difference drive and said PWM electrical-potential-difference drive according to a torque command value and said motor speed-detection value,

The motor control approach characterized by loss of said square wave electrical-potential-difference drive and said PWM wave electrical-potential-difference drives choosing little direction in having the loss map of the motor control system the case of said square wave electrical-potential-difference drive, and in said PWM wave electrical-potential-difference drive and operating said AC motor in said staging area B.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]
Especially this invention improves the performance of a motor about motor control equipment and an approach.
[0002]
[Description of the Prior Art]
The direct current power of a dc-battery is changed into alternating current power with an inverter, it is impressed by the three-phase alternating current motor, and the motor control equipment which drives a motor is known (for example, refer to JP,2000-358393,A). The square wave control which impresses and drives the driver voltage of a square wave on a motor with this equipment, PWM control which impresses and drives the driver voltage of an PWM wave on a motor is enabled. The command value of the 3-phase alternating-current voltage according to the torque command value of a motor is computed, when the alternating-voltage command value is larger than one half of the amplitude of the subcarrier which generates an PWM wave, square wave control is performed, and PWM control is performed when an alternating-voltage command value is 1/2 or less [of the amplitude of a subcarrier].
[0003]
[Problem(s) to be Solved by the Invention]
However, since square wave control and PWM control were switched for the electrical-potential-difference command value impressed to a motor only with the size relation with conventional motor control equipment as compared with the predetermined value (1/2 of the amplitude of the subcarrier for PWM wave generation), the operation effectiveness of a motor was not good.
[0004]
The purpose of this invention is to offer the motor control equipment and the approach of switching a square wave electrical-potential-difference drive and an PWM wave electrical-potential-difference drive so that the operation effectiveness of a motor may improve.
[0005]
[Means for Solving the Problem]
The square wave electrical-potential-difference drive which this invention impresses a square wave electrical potential difference at an AC motor, and is driven, The field A which performs an PWM wave electrical-potential-difference drive in order to enable the PWM wave electrical-potential-difference drive which impresses and drives an PWM (Pulse Density Modulation) wave electrical potential difference to an AC motor and to obtain a high-speed response for the operating range of an AC motor with torque and a rate It classifies into the staging area B which can drive square wave electrical-potential-difference either Field C and the PWM wave electrical-potential-difference drive which perform a square wave electrical-potential-difference drive in order to obtain high power, or a drive. In case a square wave electrical-potential-difference drive and an PWM electrical-potential-difference drive are switched according to a torque command value and a motor speed detection value In having the loss map of the motor control system the case of a square wave electrical-potential-difference drive, and in an PWM wave electrical-potential-difference drive and operating an AC motor in a staging area B, loss of a square wave electrical-potential-difference drive and the PWM wave electrical-potential-difference drives chooses little direction.
[0006]

[Effect of the Invention]
According to this invention, the operation effectiveness of a motor can be raised.
[0007]
[Embodiment of the Invention]
Drawing 1 shows the configuration of the gestalt of 1 operation. The drive control device of the electric vehicle of the gestalt of 1 operation is equipped with the motor controller 4 which controls an inverter 3 based on Currents iu, iv, and iw and the rotation signal of the inverter 3 which changes the direct current power of a dc-battery 1 into alternating current power, and is supplied to a motor 2, and a torque command taur and a motor 2. In addition, although the gestalt of this 1 operation shows the example which used the three-phase-circuit synchronizing motor to a motor 2, a motor 2 is not limited to a three-phase-circuit synchronizing motor, for example, can use a three-phase-circuit induction motor etc. An inverter 3 switches by power conversion components, such as IGBT, according to the switching signals Pu, Pv, and Pw from the motor controller 4, and changes the direct current power of a dc-battery 1 into alternating current power.
[0008]
The motor controller 4 is equipped with circumference components, such as a microcomputer, an A/D converter, and memory, and constitutes two or more control block later mentioned with the software gestalt and hardware device of a microcomputer. The motor controller 4 impresses the square wave electrical potential difference of 180 electrical angle energization to a motor 2, is equipped with the square wave control system which carries out drive control, and the PWM control system which impresses a Pulse-Density-Modulation (PWM) wave electrical potential difference to a motor 2, and carries out drive control, and switches square wave control and PWM control based on the currents iu, iv, and iw of torque command taur and a motor 2, and rate omegam.
[0009]
The square wave control system is equipped with the electrical-potential-difference phase operation part 5, the switch selection section 6, and the magnetic pole location / motor speed detector 8. The electrical-potential-difference phase operation part 5 has memorized the table of dq shaft current command value id* beforehand set up to torque command value taur and motor rate omegam, and iq*, and carries out the table search operation of dq shaft current command value id* corresponding to current torque command value taur and motor rate omegam, and iq* from this dq shaft current command value table. And based on this dq shaft current command value id* and iq*, the electrical-potential-difference phase gamma is computed by the following approach.
[0010]
In q shaft orientations which intersect perpendicularly electrically to d shaft which is the direction of the magnetic pole location theta of a motor 2, back EMF omegamphi (phi is magnetic magnetic flux) occurs. It becomes the electrical potential difference which compensates this back EMF omegamphi, and the electrical potential difference which the sum with voltage component omegamLdid (Ld is d shaft INDAKU dance) by the d shaft current id impresses to q shaft orientations. On the other hand, about d shaft orientations, voltage component omegamLqiq (Lq is q shaft INDAKU dance) by the q shaft current iq becomes applied voltage. Therefore, as shown in drawing 2 , those vector sums are the electrical-potential-difference command vectors Vr, and the phase of Vr seen from d shaft is gamma. The electrical-potential-difference phase operation part 5 computes the electrical-potential-difference phase gamma by performing vector operation shown in drawing 2 .
[0011]
The switch selection section 6 determines the switching signals Pu, Pv, and Pw of U, V, and W phase based on the electrical-potential-difference phase gamma and the motor magnetic pole location theta. An inverter 3 generates the electrical potential difference according to these switching signals Pu, Pv, and Pw, and impresses it to the three-phase-circuit synchronizing motor 2.
[0012]
Drawing 2 - drawing 5 explain the generation method of the switching signals Pu, Pv, and Pw by the switch selection section 6. In drawing 2 , when the phase of the electrical-potential-difference command vector Vr is seen from the rest frame on the basis of alpha shaft, it is thetav which is the sum of the magnetic pole location theta of a motor 2, and the electrical-potential-difference phase gamma. In order to perform square wave control of energization 180 degrees, as shown in drawing 3 , it divides into the six sections 1 which have a different switching pattern for every 60 electrical angles -, i.e., the section, and the section 6.

[0013]
The switching pattern for every section is shown in drawing 4 . For example, switching signals Pu, Pv, and Pw are given so that the section 1 will come if phase thetav of the electrical-potential-difference command vector Vr is the range which is -30 degree -30 degree, U phase may become a forward electrical potential difference and V phase and W phase may become a negative electrical potential difference. The electrical-potential-difference command vector Vr shown in drawing 2 is contained in the range of the section 3 so that clearly from the section division shown in drawing 3 . Therefore, switching signals Pu, Pv, and Pw are outputted so that it may become a forward electrical potential difference, the switching pattern, i.e., V phase, of the section 3 shown in drawing 4 , and U phase and W phase may become a negative electrical potential difference.

[0014]
Drawing 5 is a flow chart which shows processing of the switch selection section 6. In step 101, it asks for phase thetav of the electrical-potential-difference command vector Vr by the sum of the magnetic pole location theta of a motor 2, and the electrical-potential-difference phase gamma. At continuing step 102, phase thetav of the electrical-potential-difference command vector Vr judges into which section of the six sections shown in drawing 4 it goes. Furthermore, at step 103, the switching pattern of the section when phase thetav of the electrical-potential-difference command vector Vr is contained is chosen from the table shown in drawing 4 , the switching signals Pu, Pv, and Pw of this switching pattern are generated, and it outputs to an inverter 2.

[0015]
A magnetic pole location / motor speed detector 8 detects the magnetic pole location theta of a motor 2, and rate omegam based on the output signal of the resolver 9 connected with the output shaft of a motor 2. In addition, although the gestalt of this 1 operation shows the example using the resolver as a sensor which detects rotation of a motor 2, a motor rotation sensor is not limited to a resolver, for example, may use an encoder and a pulse generator. Moreover, this magnetic pole location / motor speed detector 8 are taken as common use by the square wave control system and the PWM control system.

[0016]
Next, an PWM control system is explained. The PWM control system is equipped with the efficient current table 10, the current control section 11, 2 phase three-phase-circuit transducer 12, the three-phase-circuit 2 phase transducer 13, the PWM transducer 17, and the magnetic pole location motor speed detector 8.

[0017]
The efficient current table 10 is equipped with the efficient current table beforehand set up to torque command taur and motor rate omegam, and computes dq shaft current command value id* corresponding to current torque command value taur and motor rate omegam, and iq* from this efficient current table. The current control section 11 calculates electrical-potential-difference command value vd* of dq shaft for making dq shaft actual current id and iq in agreement with dq shaft current command value id* and iq*, and vq* by the PI control shown in a degree type.

[Equation 1]
vd*=Kpd(id*-id)+Kidintegral(id*-id) dt,
vq*=Kpq(iq*-iq)+Kiqintegral(iq*-iq) dt
In a formula 1, the proportional gain of dq shaft current control, and Kid and Kiq of Kpd and Kpq are the integral gain of dq shaft current control.

[0018]
2 phase three-phase-circuit transducer 12 changes dq shaft electrical-potential-difference command value vd* and vq* into 3-phase-alternating-current-voltage command vu*, vv*, and vw* based on the magnetic pole location theta of a motor 2. The three-phase-circuit 2 phase transducer 13 changes into dq shaft actual current id and iq the three-phase alternating current iu, iv, and iw detected by current sensors 14, 15, and 16 based on the magnetic pole location theta of a motor 2. The PWM transducer 17 generates switching signals Pu, Pv, and Pw for 3-phase-alternating-current-voltage command vu*, vv*, and vw* as compared with an about 10kHz subcarrier (generally triangular wave).

[0019]
Next, switch actuation with square wave control and PWM control is explained. The control change-over section 18 controls the switch SW2 installed in the switch SW1 installed in the input section of a square wave control system, and the output section, and the switch SW4 installed in the switch SW3 installed in the

input section of an PWM control system, and the output section, and switches square wave control and PWM control.

[0020]

Drawing 6 shows torque command taur, the square wave regulatory region on the 2-dimensional flat surface of motor rate omegam, and PWM regulatory region. Field A is a field which performs only PWM control, and Field C is a field which performs only square wave control.

[0021]

Generally, the control by the square wave electrical potential difference has responsibility bad at the time of transient change to which torque command taur and motor rate omegam change suddenly compared with control by the PWM wave electrical potential difference, although it excels in respect of the electrical-potential-difference utilization factor compared with control by the PWM wave electrical potential difference and high power is obtained. It is more desirable to perform PWM control with responsibility more sufficient [Field A has torque command taur and motor rate omegam smaller than they in Field C, and] since the motor output P (**taur-omegam) is operated in the condition lower than a horsepower output Pmax than the square wave control for obtaining high power. On the contrary, it is more desirable to perform square wave control for responsibility to obtain high power rather than good PWM control, since Field C has torque command taur and motor rate omegam larger than they in Field A and the motor output P (**taur-omegam) is operated in the condition near a horsepower output Pmax. Therefore, the operating range of the current motor 2 is judged based on torque command taur and motor rate omegam, and control is switched.

[0022]

On the other hand, square wave control and PWM control are both the fields which can be performed, and Field B chooses either. In this field B, a control system with high operation effectiveness is chosen that there is little loss. Thereby, the mileage per 1 charge of an electric vehicle can be lengthened. However, when the quick response of control when the response of the motor torque in square wave control or a motor current has a sudden change of disturbance torque or a torque command since it is late compared with the response of PWM control as mentioned above is calculated, even if operation effectiveness becomes low, the PWM control which shows quick responsibility will be chosen, and stabilization of control is planned.

[0023]

Drawing 7 is a flow chart which shows the control change-over actuation in the control change-over section 18 of the gestalt of 1 operation. In step 201, either is chosen from the operating range A, B, and C shown in drawing 6 based on present torque command taur (n) and present motor rate omega m (n). At step 202, it checks whether current torque command taur (n) and current motor rate omega m (n) is in a operating range C, when it is in a operating range C, it progresses to step 210, otherwise, it progresses to step 203.

[0024]

It checks whether when there is nothing into a operating range C, torque command taur (n) and motor rate omegam current at step 203 are in a operating range A, when it is in a operating range A, it progresses to step 214, otherwise, it progresses to step 204. When current torque command taur (n) and motor rate omegam are in a operating range A, PWM control is chosen at step 214. About selection actuation of this PWM control, it mentions later.

[0025]

When there is no operating point of the motor 2 decided by current torque command value taur (n) and motor rate omegam into Field A and there is nothing also into Field C again, the loss Lp at the time of performing Loss Lk and PWM control at the time of performing square wave control based on torque command taur (n) and motor rate omega m (n) at step 204 is calculated.

[0026]

Here, the loss Lk by square wave control and the loss Lp by PWM control are considered. The loss Lp by the PWM control with many the count of switching, i.e., the count which repeats ON and OFF, of loss in case the power conversion component of an inverter 3 carries out switching operation is larger than the loss Lk by square wave control. However, the loss Lk by the square wave control with the long period which has flowed of loss in case switch-on has on resistance loss of a power conversion component, i.e., a power conversion component, is larger than the loss Lp by PWM control. On the other hand, a square wave is impressed to a motor 2 by square wave control to considering motor loss, the driver voltage near a sine wave being impressed to a motor 2 by PWM control, and the motor loss by square wave control is larger than the motor loss by PWM control at **.

[0027]
When these are judged synthetically, the inclination for the direction of the loss Lk by square wave control to become smaller than the loss Lp by PWM control is shown, but since loss changes with the classes of the power conversion component to be used or motor, in Field C, it cannot generally be said that which is good. Therefore, with the gestalt of this 1 operation, it memorizes in the memory (un-illustrating) which searches for loss by the various square wave control and the PWM control according to conditions by a paper operation and a paper experiment, map-izes, and is built in the motor controller 4, and this map table is referred to if needed.
[0028]
Drawing 8 shows an example of the loss map by PWM control and square wave control. In this example of a loss map, torque command taur (tau 0 - taumax) is arranged in a column, motor rotational-speed omegam (omega 0 - omegamax) is arranged to infestation, respectively, and the loss map by the PWM control which recorded loss data on each column, and the loss map by square wave control are shown. From these map data, the loss corresponding to current torque command taur (n) and current motor rate omega m (n) is searched for by the linear interpolation operation.
[0029]
For example, current torque command taur (n) is between tau7 and tau8, and when motor rate omega m (n) is between omega6 and omega7, four data Lp11, Lp12, Lp21, and Lp22 surrounding the operating point of current torque command taur (n) and current motor rate omega m (n) are first read from the loss map by PWM control. And the linear interpolation operation by torque command taur is performed, and the loss Lp1 and Lp2 corresponding to torque command taur (n) is searched for.
[Equation 2]
Lp1=Lp11+(Lp12-Lp11)/(tau8-tau7) - (taur(n)-tau7),
Lp2=Lp21+(Lp22-Lp21)/(tau8-tau7) - (taur(n)-tau7),
Furthermore, linear interpolation by motor rate omegam is performed, and the loss Lp by the PWM control corresponding to torque command taur (n) and motor rate omega m (n) is searched for.
[Equation 3]
Lp=Lp1+(Lp2-Lp1)/(omega7-omega6) - (omegam(n)-omega6)
[0030]
Next, four data Lk11, Lk12, Lk21, and Lk22 surrounding the operating point of current torque command taur (n) and current motor rate omega m (n) are read from the loss map by square wave control. And the linear interpolation operation by torque command taur is performed, and the loss Lk1 and Lk2 corresponding to torque command taur (n) is searched for.
[Equation 4]
Lk1=Lk11+(Lk12-Lk11)/(tau8-tau7) - (taur(n)-tau7),
Lk2=Lk21+(Lk22-Lk21)/(tau8-tau7) - (taur(n)-tau7),
Furthermore, linear interpolation by motor rate omegam is performed, and the loss Lk by the square wave control corresponding to torque command taur (n) and motor rate omega m (n) is searched for.
[Equation 5]
Lk=Lk1+(Lk2-Lk1)/(omega7-omega6) - (omegam(n)-omega6)
[0031]
It progresses to step 205, after calculating torque command taur (n), the loss Lk of the square wave control corresponding to motor rate omega m (n), and the loss Lp of PWM control at step 204 of drawing 7 . Step 205 compares the loss Lk by square wave control, and the loss Lp by PWM control, when the square wave control loss Lk is smaller than the PWM control loss Lp, it progresses to step 206 that square wave control should be chosen, and when the PWM control loss Lp is conversely smaller than the square wave control loss Lk, it progresses to step 214 that PWM control should be chosen. About selection actuation of PWM control, it mentions later.
[0032]
When the square wave control loss Lk is smaller than the PWM control loss Lp, it is step 206 and the change part absolute value deltataur (= |taur(n)-taur(n-1) |) of torque command taur is compared with the predetermined value A. Here, the predetermined value A is the variation of the limitation which can answer quickly enough by square wave control last time this time at the time of change to torque command tau[at the time of a sampling] r (n) from torque command taur at the time of a sampling (n-1). When the torque

command variation absolute value deltataur is larger than the predetermined value A, in square wave control, it judges that a response is slow, and responsibility is thought as important and it progresses to step 214 that PWM control should be chosen. On the other hand, when the variation absolute value deltataur of torque command taur is below the predetermined value A, it progresses to step 207 that square wave control should be chosen noting that it can answer quickly enough by square wave control.

[0033]

At step 207, change part deltaid (=|id(n)-id(n-1) |) of dq shaft current and deltaiq= (|iq(n)-iq(n-1) |) are detected, and parts for these change delta id and delta iq are compared with the predetermined values B and C, respectively. Here, q shaft current change part [when d shaft current change part deltaid changes only in the predetermined value B] deltaiq sets the value which becomes larger than the predetermined value A which the variation of motor torque mentioned above to the predetermined values B and C, when only the predetermined value C changes. d shaft current change part deltaid is larger than the predetermined value B, or when q shaft current change part deltaiq is larger than the predetermined value C, it judges that disturbance entered and progresses to step 214, and since it answers quickly at the time of disturbance mixing and corresponds to it, PWM control is chosen. d shaft current change part deltaid is below the predetermined value B, and on the other hand, since there is no mixing of disturbance when q shaft current change part deltaiq is below the predetermined value C, it is not necessary to choose PWM control, and it progresses to step 208 that square wave control should be chosen.

[0034]

At step 208, based on motor torque command taur, the variation deltaomegam1 of motor rate omegam is predicted, this motor rate variation forecast deltaomegam1 and the variation deltaomegam2 of actual motor rate omegam are measured, and the existence of disturbance is judged based on a comparison result. Speed-difference deltadeltaomegam of the motor rate variation forecast deltaomegam1 and the variation deltaomegam2 of actual motor rate omegam is calculated by the degree type.

[Equation 6]

deltadeltaomegam=|deltaomegam1-deltaomegam2|,

deltaomegam1=taur(n-1) -deltat/J (deltat: sampling time, J:inertia)

deltaomegam2=omegam(n)-omegam (n-1)

With a forecast, motor speed-difference deltadeltaomegam with a value actually judges with those with disturbance invasion, when larger than the predetermined value D, it progresses to step 214, and since it answers quickly at the time of disturbance mixing and corresponds to it, PWM control is chosen. On the other hand, it judges with there being no disturbance mixing, and a forecast and when motor speed-difference deltadeltaomegam with a value is actually below the predetermined value D, since it is not necessary to choose the PWM control with sufficient responsibility, it progresses to step 209 that square wave control should be chosen. Here, the value with which the following relation is filled to the above-mentioned torque variation A which can answer by square wave control is set to the predetermined value D.

[Equation 7]

D>=|(A-delta t/J) |

[0035]

When switching to square wave control from PWM control, in order to prevent a torque shock and to perform a smooth switch, where PWM control is stabilized, it switches to square wave control. On the contrary, when switching to PWM control from square wave control, in order not to spoil the fast response by PWM control, it switches to PWM control in an instant.

[0036]

At step 209, it is checked whether before shifting to square wave control, PWM control has been performed beyond predetermined time. Square wave control counter CNTk is not 0, and last time is not square wave control, and when PWM control counter CNTp is smaller than the predetermined value E, since PWM control is not performed beyond predetermined time yet, in order to continue PWM control as it is, specifically, it progresses to step 214. On the other hand, square wave control counter CNTk is not 0, or when PWM control counter CNTp is beyond the predetermined value E, it judges that you may switch to square wave control immediately, and progresses to step 213. Here, the time amount more than the response time of the torque control of PWM control or current control is set to the predetermined value E.

[0037]

The existence of disturbance is checked, although square wave control is fundamentally performed when the

operating point decided by current torque command taur (n) and current motor rate omega m (n) is in Field C. At step 210, change part deltaid (=|id(n)-id(n-1) |) of dq shaft current and deltaiq= (|iq(n)-iq(n-1) |) are detected, and it compares with the predetermined values B and C which mentioned above parts for these change delta id and delta iq, respectively. d shaft current change part deltaid is larger than the predetermined value B, or when q shaft current change part deltaiq is larger than the predetermined value C, it judges that disturbance entered and progresses to step 212, and in order to prevent the overcurrent by disturbance, torque command taur is restricted to the maximum of the PWM control in motor rate omega m (n).

[Equation 8]

taur(n) =taupmax [omegam (n)]

Then, it progresses to step 214, and since it answers quickly at the time of disturbance mixing and corresponds to it, PWM control is performed.

[0038]

d shaft current change part deltaid is below the predetermined value B, and on the other hand, when q shaft current change part deltaiq is below the predetermined value C, it progresses to step 211, and motor speed-difference deltadeltaomegam with a value is actually calculated with a forecast with the above-mentioned formula 6, and the existence of the disturbance predicted from the motor rate is judged. As it actually judges with those with disturbance invasion with a forecast when larger than the predetermined value D, and it progresses to step 212 and it is shown in the above-mentioned formula 8, in order that motor speed-difference deltadeltaomegam with a value may prevent the overcurrent by disturbance, torque command taur is restricted to the maximum of the PWM control in motor rate omega m (n). Then, it progresses to step 214, and since it answers quickly at the time of disturbance mixing and corresponds to it, PWM control is performed.

[0039]

Since it is not necessary to judge with having no disturbance mixing and to choose the PWM control with sufficient responsibility when motor speed-difference deltadeltaomegam with a value is actually below the predetermined value D, a forecast and, it progresses to step 213 that square wave control should be chosen.

[0040]

At step 213, close [of the switches SW1 and SW2 shown in drawing 1] is carried out, off [of the switches SW3 and SW4] is carried out, and square wave control is chosen and carried out. And PWM control counter CNTp is reset to 0, and 1 is set as square wave control counter CNTk.

[0041]

On the other hand, at step 214, off [of the switches SW1 and SW2 shown in drawing 1] is carried out, close [of the switches SW3 and SW4] is carried out, and PWM control is chosen and carried out. And PWM control counter CNTp is incremented and square wave control counter CNTk is reset to 0.

[0042]

According to the gestalt of 1 operation mentioned above, when operation effectiveness improves and it applies to an electric vehicle by choosing a motorised control system with little loss, the consecutiveness distance becomes long.

[0043]

According to the gestalt of 1 operation, activation of both square wave control (square wave electrical-potential-difference drive) and PWM control (PWM wave electrical-potential-difference drive) is enabled at a middle operating range B. Moreover, when the variation of a torque command is large, Or by choosing and performing PWM control, when disturbance invades, and a fast response (high-speed response) is searched for Since a torque response is not reduced, an operator's sense of incongruity can be prevented upwards and the flattery nature of control becomes good by PWM control, the overcurrent by the response delay of current control can be prevented. Since square wave control is chosen and performed when a fast response is not searched for in a middle operating range B, an electrical-potential-difference utilization factor becomes high, and high power is obtained.

[0044]

An operator seems moreover, to be able to prevent a torque shock and not to sense sense of incongruity, since it was made to switch when switching to square wave control from PWM control after checking that PWM control had been stabilized.

[0045]

Furthermore, since a torque command is restricted to the value according to a motor rate, a torque command

is reduced and it was made to switch to PWM control when disturbance invaded in the operating range C of square wave control, the flattery nature of control becomes good and can prevent the overcurrent by the response delay of current control.

[0046]

The correspondence relation between the component of a claim and the component of the gestalt of 1 operation is as follows. The electrical-potential-difference phase operation part 5, the switch selection section 6, the magnetic pole location / motor speed detector 8, and an inverter 3 namely, a square wave electrical-potential-difference drive circuit The efficient current table 10, the current control section 11, 2 phase three-phase-circuit transducer 12, the PWM transducer 17, the three-phase-circuit 2 phase transducer 13, the magnetic pole location / motor speed detector 8, and an inverter 3 an PWM driver voltage circuit A resolver 9, and the magnetic pole location / motor speed detector 8 a rate detector